# Analysis of Thermal Detection Prediction Capability of FDS

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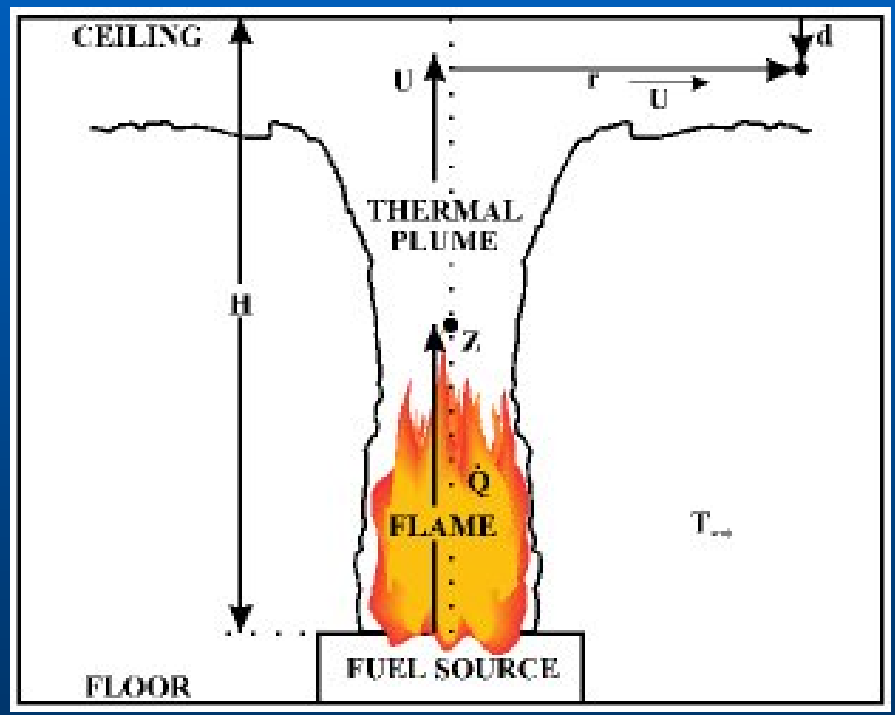
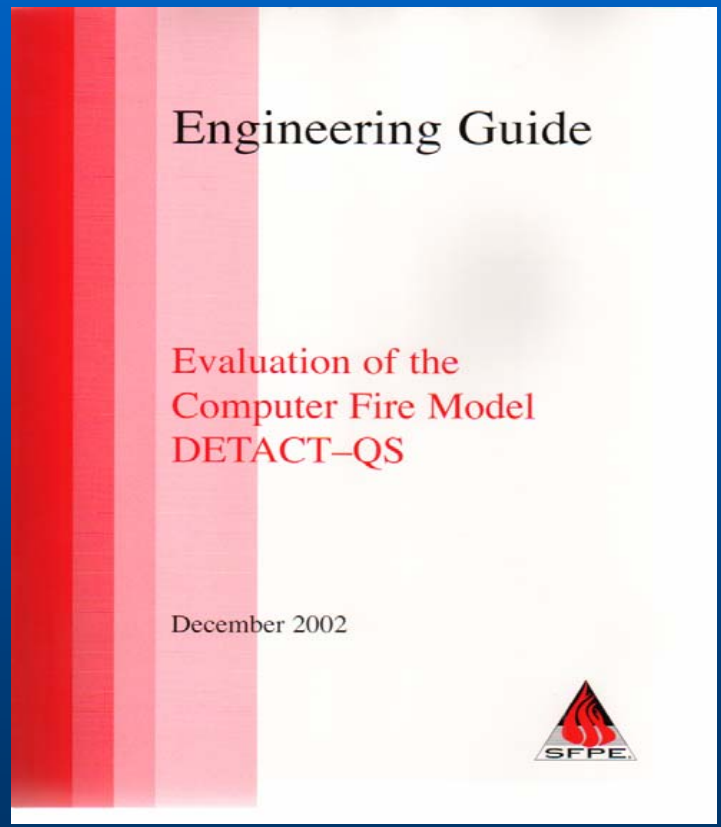
# FDS Validation

- Comparing FDS predictions to full-scale test conducted at UL
- Heptane burner located in center of room.
- Data of interest is temperature readings of heat detectors.



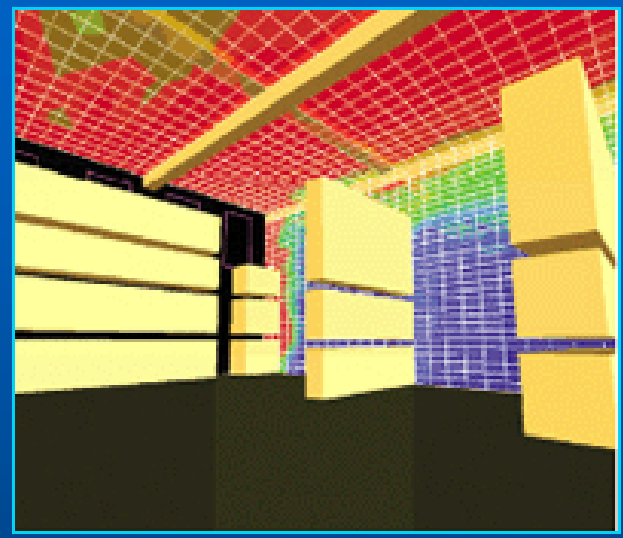
# FDS Validation

- **SFPE Task Group on Computer Model Evaluation**
- **Trends in DETACT-QS predictions were noticed**
- **Similar evaluation of FDS was of interest**



# Performance Based Design (PBD)

- Alternative to prescriptive based code solutions
- Validation work can be used by engineers to justify use of FDS in PBD



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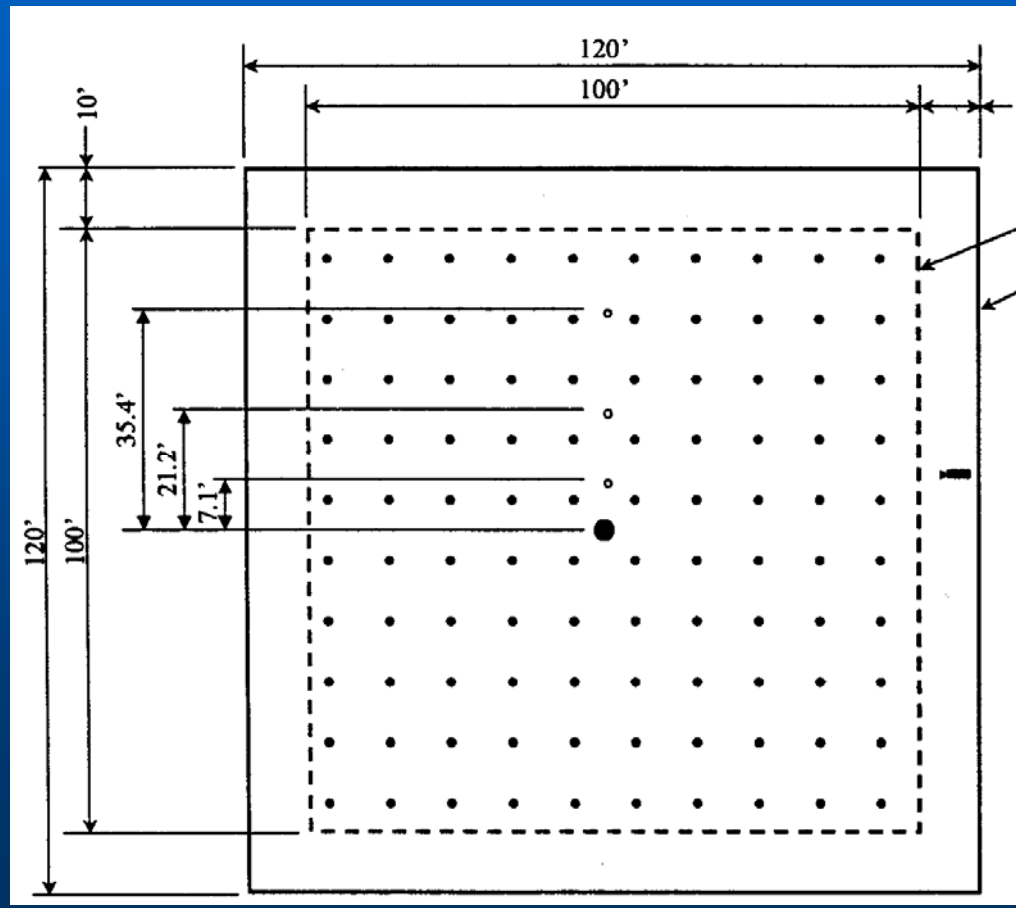
# Materials and Methods

- **Computer loaded with FDS v 4.05**
  - **3.8 GHz Pentium 4**
  - **3.2 GB RAM**
- **UL Test Publication**

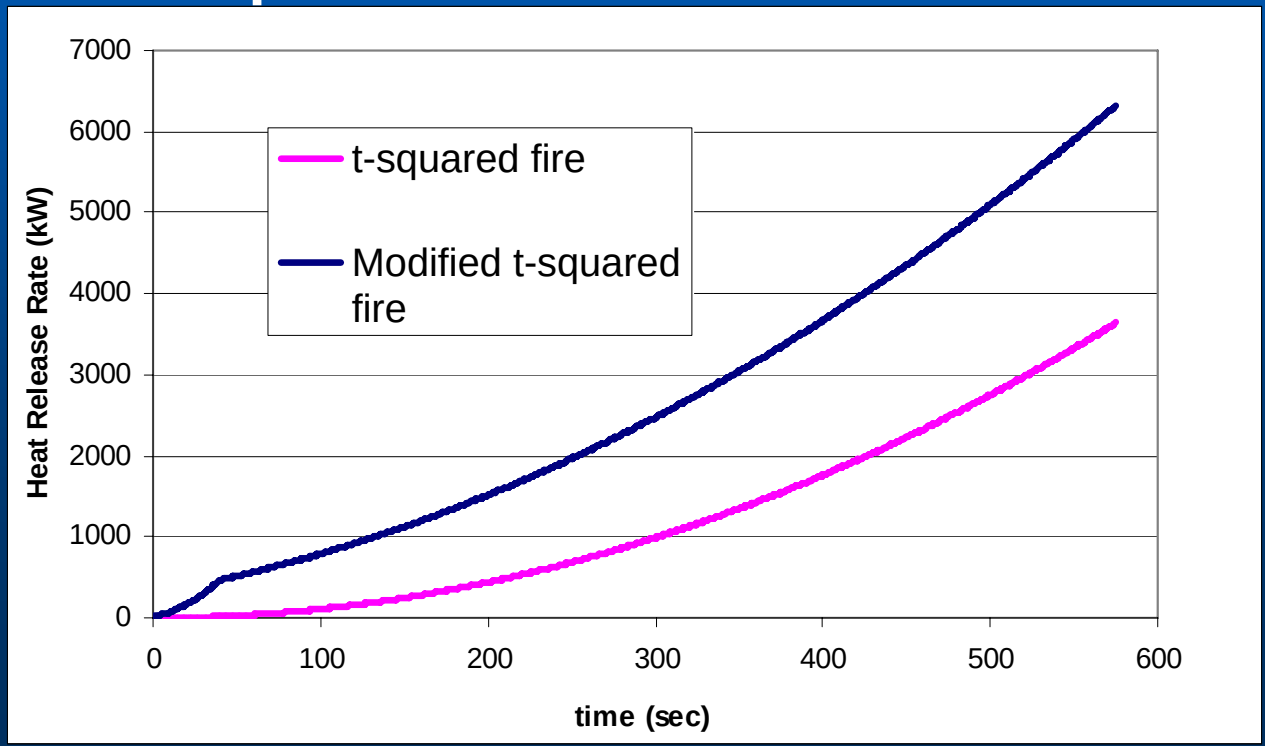
# Full-Scale Test Setup

- Conducted at Underwriters Laboratories (UL)
- Moveable ceiling
- Heptane burner located at center
- Thermocouple trees placed at different distance from fire
- Exhaust fan above ceiling



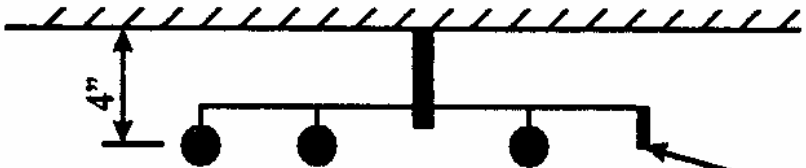
# Full-Scale Test Setup

- **Heptane spray burner**
  - **Top of burner located 0.33 m from floor**
  - **“Modified” t-squared fire**



# Full-Scale Test Setup

- 6 different runs
  - One run for each ceiling height
- 4 thermocouple trees
  - 1 at plume centerline
  - 3 at different radial distances from fire



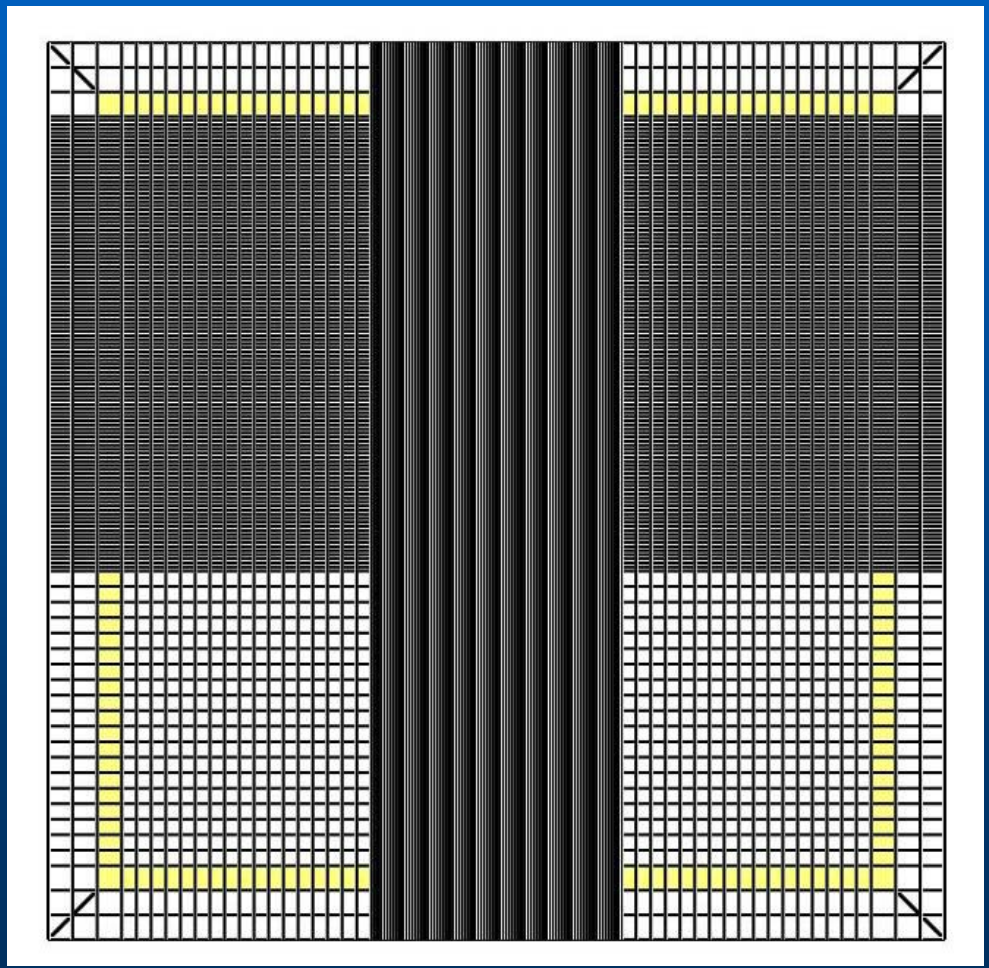

Slow, medium, fast disk thermocouple and
0.6025" Type K inconel sheathed thermocouple

# FDS set up

- **Input parameters**
  - **Room Dimensions**
  - **Fire size (HRRPUA)**
  - **Locations of burner, TCPs, and Heat Detectors**
  - **Thermal Characteristics, i.e.: specific heat, thermal diffusivity, etc.**
  - **Grid Sizing**

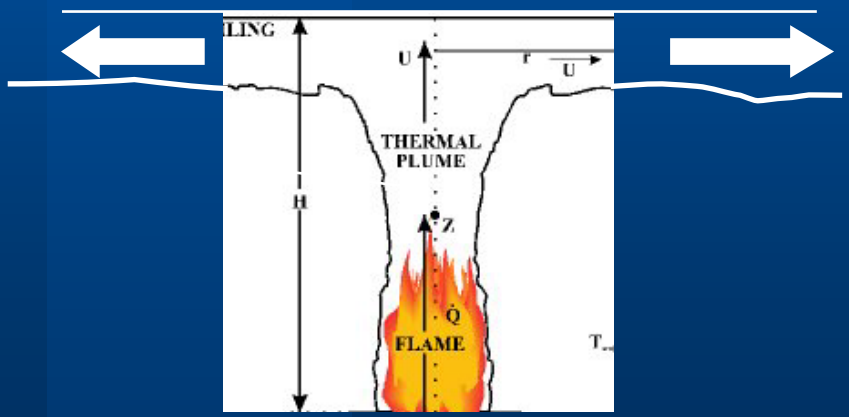
# FDS Grid Sizing

- Conversion to metric
- Wanted high resolution in vicinity of fire plume and heat detectors.
  - Grid stretched using TRNX & TRNY

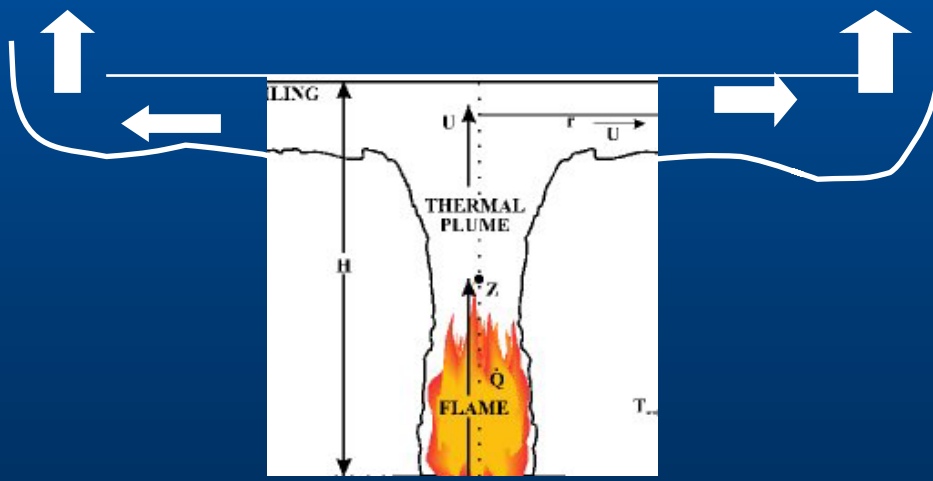


# FDS set-up

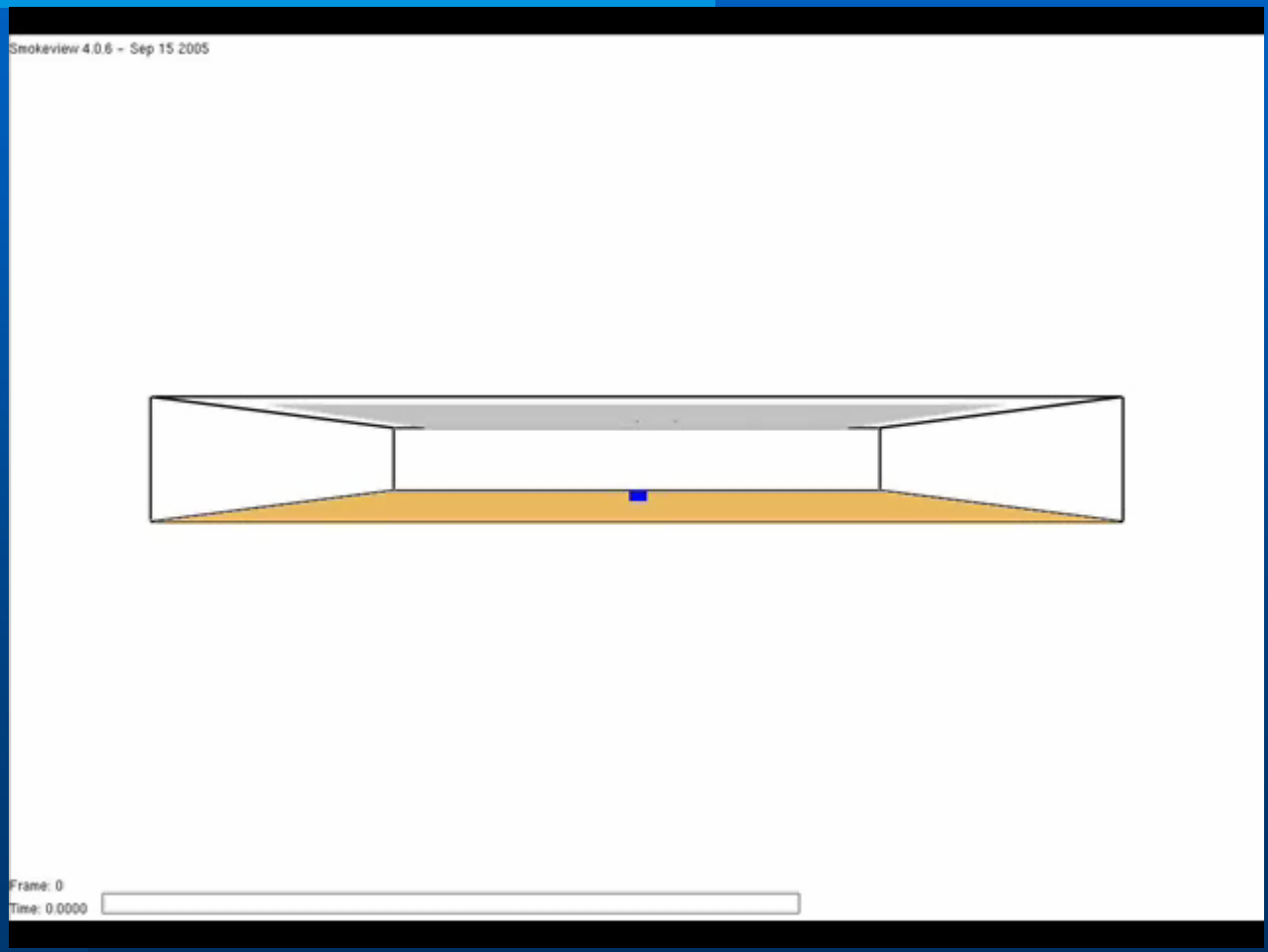
1. **Smoke leaves computational domain through side boundary**




2. **Smoke leaves computational domain through ceiling boundary**

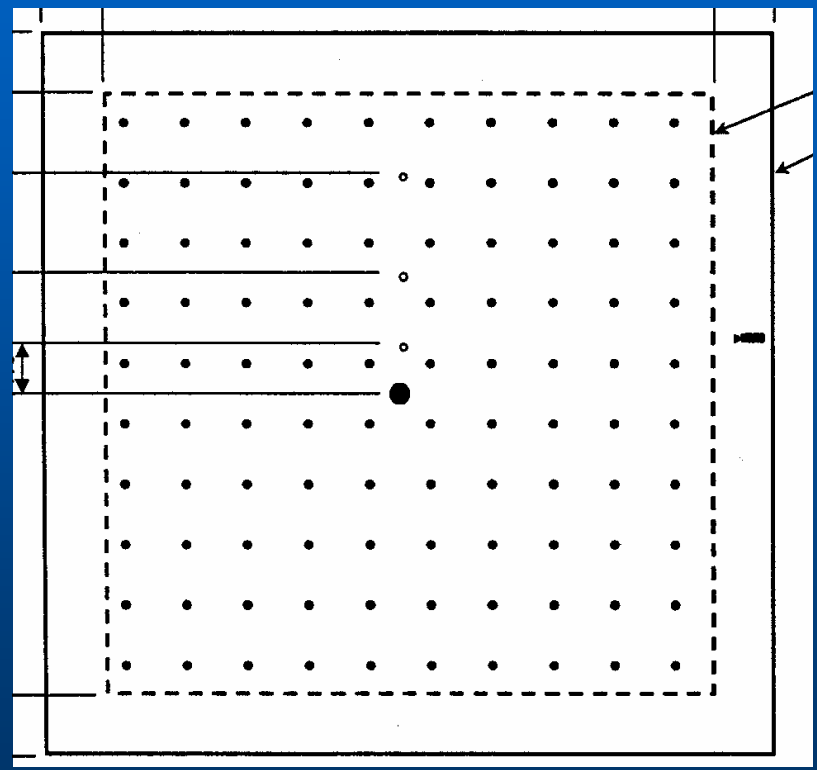


# FDS input



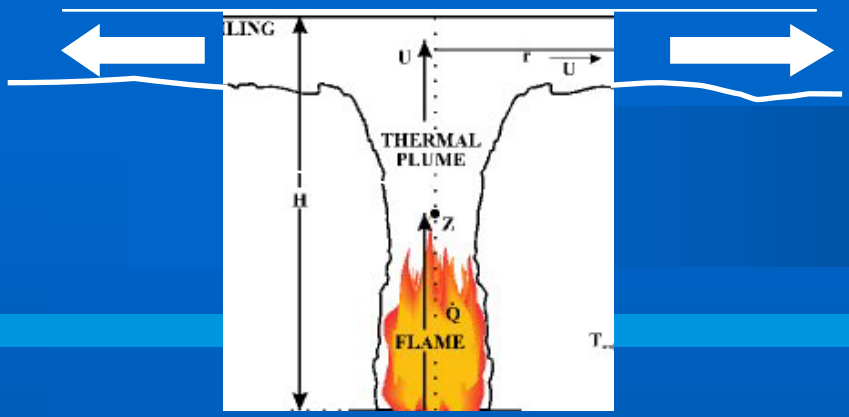
# Special Issues

- Compartment has symmetric geometry
- Initially used MIRROR command
- Found out MIRROR is not applicable due to location of MIRROR plane and because of LES (Large Eddy Simulation)



# Special Issues (cont.)

- **Expected similar temperature prediction with different boundary conditions.**
  - **Found temperature differences of heat detectors between simulations ranging from 50 °C to 150 °C.**
  - **Currently addressing this topic**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THERMAL
PLUME
H
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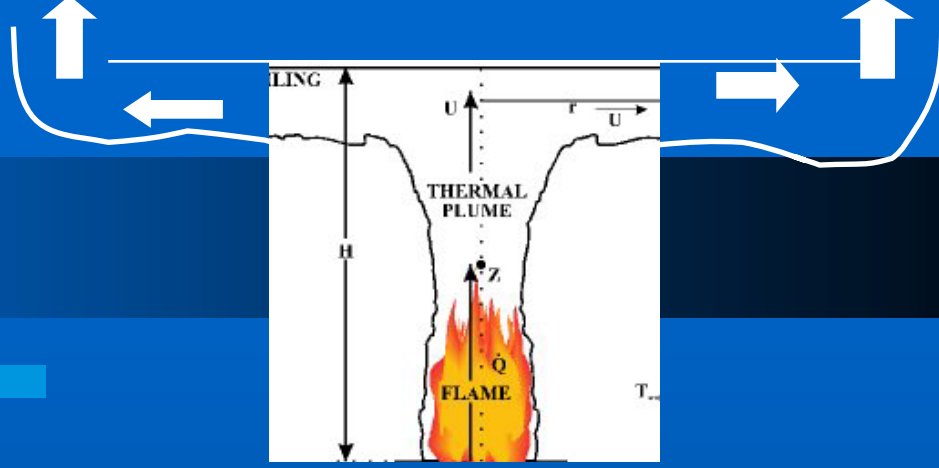
FLAME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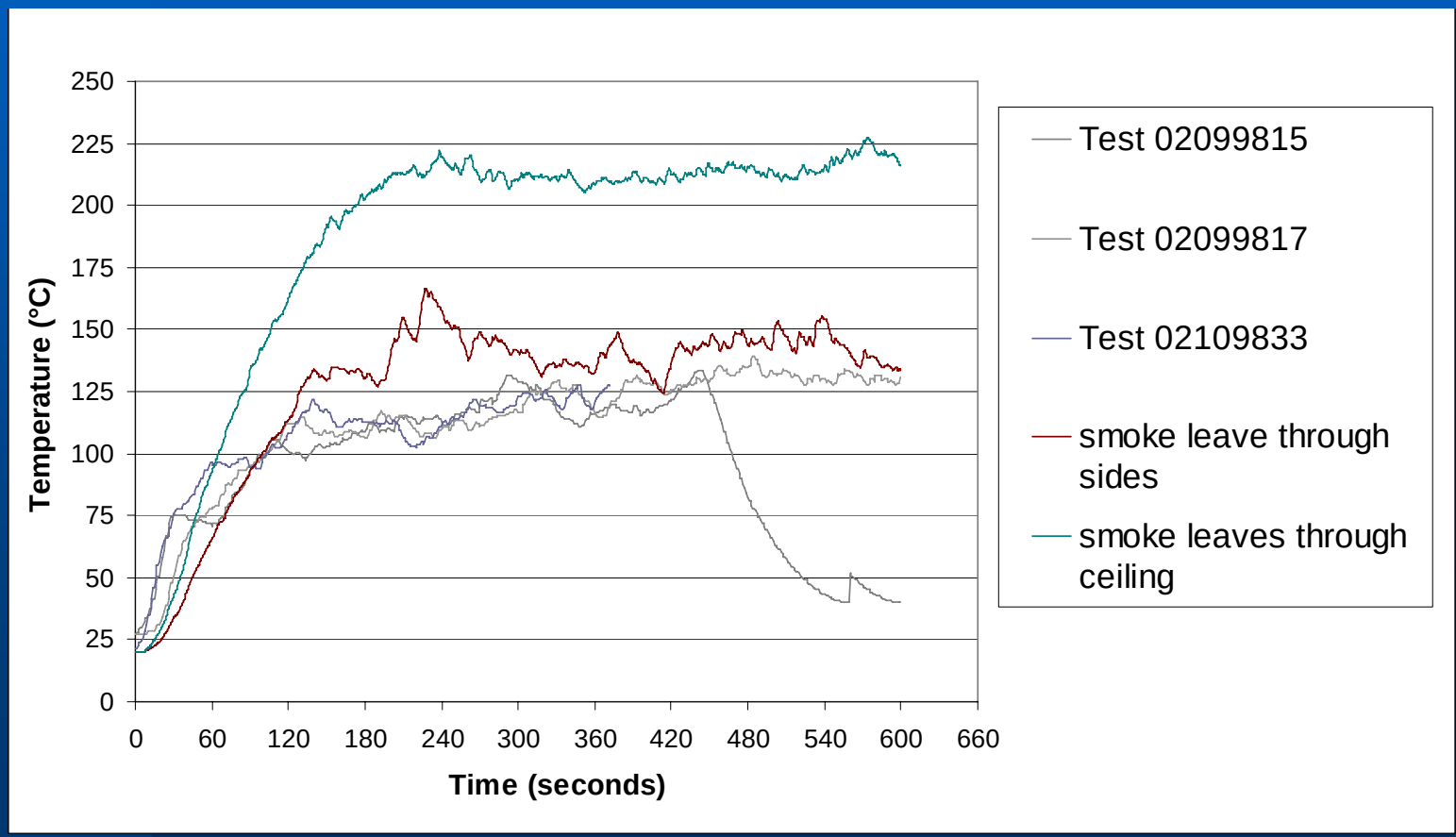
Temperature (°C)
250
225
200
175
150
125
100
75
50
25
0
0
60
120
180
240
300
360
420
480
540
600
660
Time (seconds)
Test 02099815
Test 02099817
Test 02109833
smoke leave through sides
smoke leaves through ceiling

# Uncertainty Analysis

- **Experimental Uncertainty**
  - **Heptane Flow**
  - **Measuring Devices**
  - **Repeatability**
- **Type A and Type B Analysis used**
- **Propagation of Uncertainty**
  - $Q = m_f" \times \Delta Hc$
- **Model Uncertainty**

# Work to be completed

- **Compile time-temperature curves for each trial run**
- **Compare FDS prediction with UL data in terms of uncertainty**
- **Analyze discrepancies in temperature readings**
- **Conduct grid sensitivity analysis**

# Insights Gained

- **Many issues involved in FDS modeling**
  - **Trial runs are a must!**
  - **Long run times**
    - **Run times ranged from 2 days to 4 weeks.**